Next Steps in Vehicle Electrification Technician Preparation Part V:

Introduction of the SAE Fuel Cell Systems Certification

June 25, 2021

August 16-18th, 2021

Greater Tacoma Convention Center

Registration & More Information: https://www.gtsummitexpo.com

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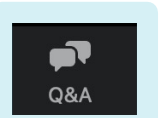
Series Sponsors

Please refer to Maddy Reznick, maddy@cwcleancities.org with any technical questions about this webinar.

Housekeeping

- Chat with other attendees in the chat box.
- Ask questions using the 

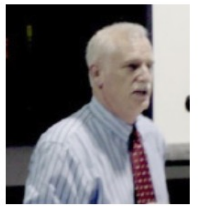
box.
- Feel free to log your question during the presentation- we'll answer these first during the Q&A section.
- Webinar recording & slide deck will be available to all attendees.

Please refer to Maddy Reznick, maddy@cwcleancities.org with any technical questions about this webinar.

Featured Speakers

Ken Mays

Professor & Director of Automotive Technology
Central Oregon Community College



John Frala

Professor Alternative Fuels
Rio Hondo College

Tim Perzanowski

NEVTEX Consultant
Rio Hondo College

Dr. Mark Quarto

Chief Technology Office
Future Tech Auto LLC.

John Frala

- Coordinates the Alternative Fuels
- Co-PI for the NEVTEX NSF grant
- Associate of Science Advanced Alternative Fuels Transportation
- Associate of Science Electric and Fuel Cell Vehicle Technology
- Certificate of Achievement in Tesla Technology
- Volvo Lights Project, Electric Class 8 Trucks
- Rivian Electric Vehicles, West Coast Training Center

Fuel Cell Vehicles and Technician Training

NSF project grant – Northwest Engineering and Vehicle Technology Exchange (NEVTEX) # 1700708

Advanced Vehicle Training Standards for technicians working with high-voltage and high-pressure systems

What we found in our grant research,

Currently there are NO uniform Standards for technicians who are working with High Voltage or High-Pressure systems.

Several existing training formats that are available are outdated by technology changes.

This has been confirmed by the industry

SAE Society of Automotive Engineers

OSHA Occupational Safety Health Administration

Department of Transportation

Department of Energy

California Energy Commission

South Coast Air Quality Management District

California Air Resources Board

CSA Canadian Safety Administration

NFPA National Fire Protection Administration

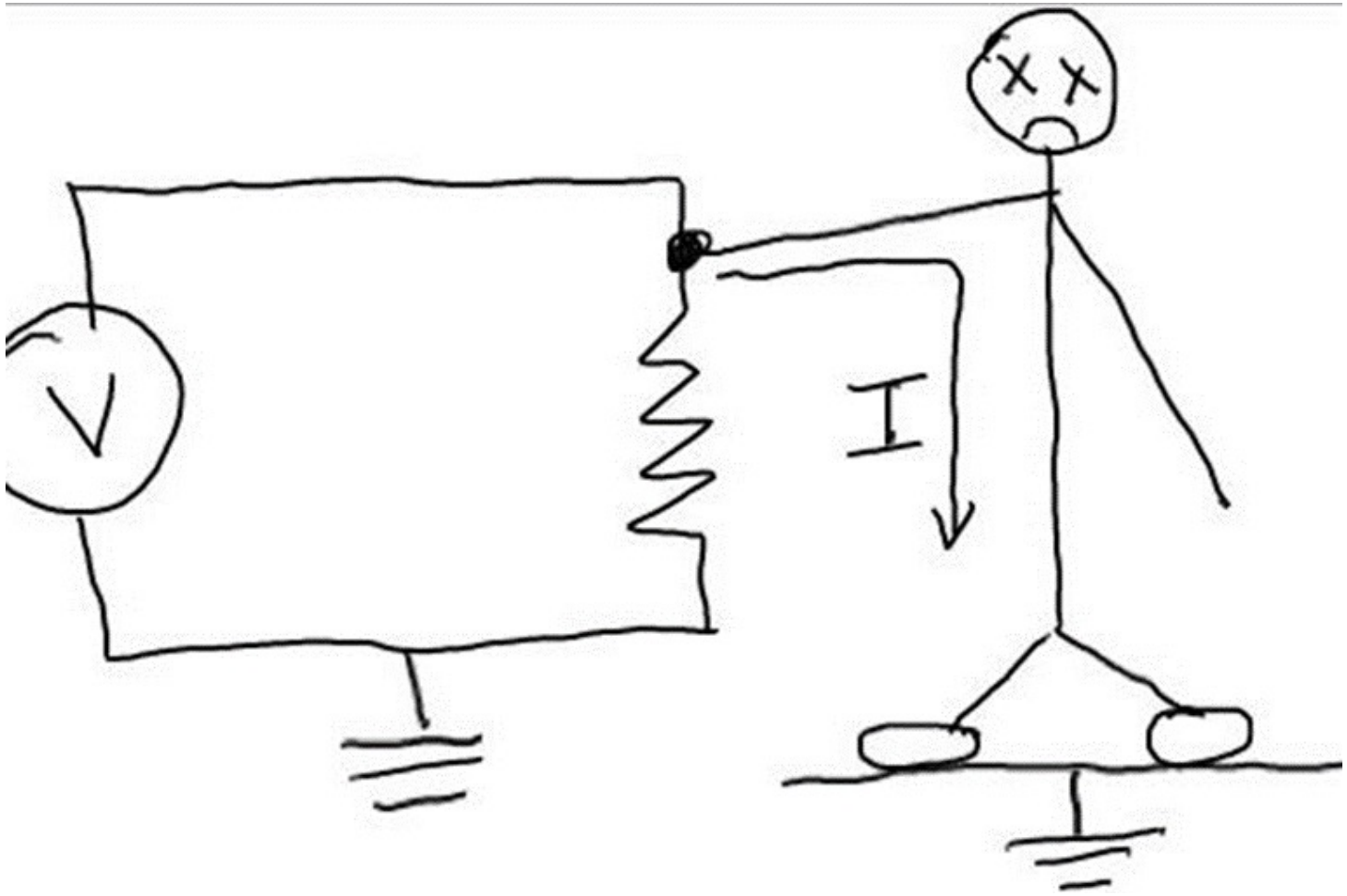
Hoke/ CiCor

Swedgelock

Several meetings with the Alternative Energy Transportation Team at CSA Group

- Establish the need for Hydrogen fuel tank inspection standards
- Establish the need for high pressure piping certification
- Establish the need for technician high voltage certificate training
- Establish uniformed standards for this certification

What's next?



This Project Grant has helped to build relationships with essential Advisory partners throughout the country. These members are truly representative of the vehicle electrification systems dealing with high-pressure storage and handling of fuels and high-voltage storage and creation.

A sample template and list of Advanced Standards categories have been established as we plan for refinement of the standards criteria.
An initial discussion has taken place as we select the first 10 test sites for the first 2 standards to be “proofed”.

This grant also opened the door for (In California) to establish the Volvo Lights training project on Class 8 Electric Truck at Rio Hondo College.

Second development was the formal MOU between the West Coast Center of Excellence and Rio Hondo College to develop training and certification participation for Transit fuel cell technicians and their managers.

Train the Trainer Level One Standards developed and now being delivered this year.
Train the Trainer Level Two Standards developed and now planning for delivering this year.

Level three is being finalized currently.

SAE/ITC certification on training to be delivered through the Probitas system.

For More Information

Northwest Engineering and Vehicle Technology Exchange (NEVTEX) (NSF ATE award #1700708)

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Central Oregon Community College Automotive Technology

Bend, Oregon

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Advanced Vehicle Training Group NW

www.avtgnw.org

CO-PI Professor John Frala jfrala@riohondo.edu

Rio Hondo Community College Alternative Fuels Education

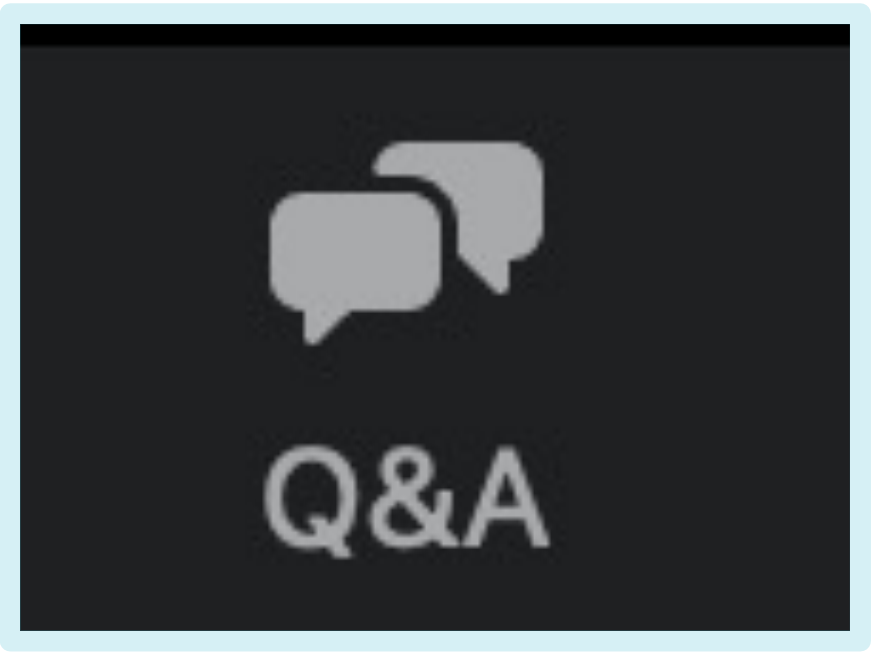
Whittier, CA.

562-463-7473

https://faculty.riohondo.edu/jfrala/

Questions?

Type your question in the questions box.



Tim Perzanowski

While working for Hughes Aircraft, Delphi, General Motors and Rivian Tim has accumulated 40 years of experience in power electronics, 27 years of experience in electric vehicles and 20 years in fuel cell electric vehicles.

During his career has been a quality engineer, manufacturing engineer, process engineer, design engineer, systems engineer and field service engineer. He spent the last 20 years as a senior project engineer responsible for training, field service and maintenance of various GM fuel cell electric, hybrid and battery electric prototype vehicles and fleets.

He has trained engineers in the US and China, GM and dealership technicians, first responders, college students and the public on the operation, diagnosis and repair of fuel cell electric vehicles both inside GM and under contract with the US Navy.

Fuel Cell Vehicles and Technician Training

NSF project grant – Northwest Engineering and Vehicle Technology Exchange (NEVTEX) # 1700708

Why Fuel Cells

- Fuel cell vehicles are electric vehicles
- Viable low or zero emission vehicle
- Allows the use of excess renewable energy to create a transportation fuel that can be stored and transported
- Allows a time shift of hours or days between power generation and vehicle refueling
- About 2x the efficiency of a gasoline engine
- The only emission is water vapor
- Allows long range (hundreds of miles) and quick fill-ups (3-5 minutes) for an electric vehicle

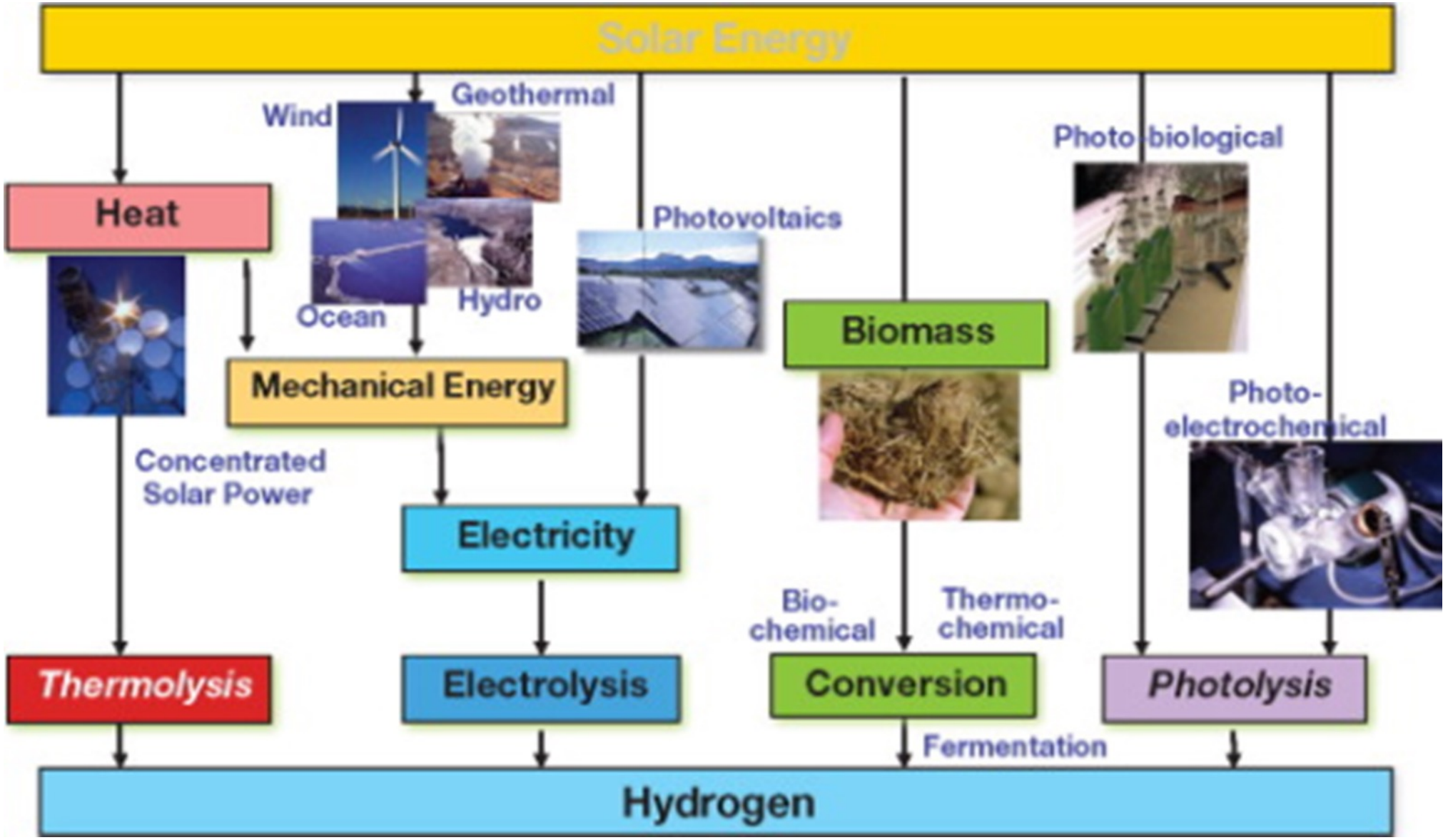
Similarities Between Fuel Cell and other Vehicles

- Electronics and powertrains like a battery electric and strong hybrid vehicles
- May or may not have a high voltage battery
- Compressed gas storage, regulation and metering similar to natural gas vehicles
- Air machines and compressors similar to turbochargers and electric superchargers
- Mass flow, temperature and pressure sensors
- Heat exchangers and coolant
- ECUs similar to ECM and BEV controllers

Unique Qualities of Hydrogen Fuel Cell Vehicles

- How a fuel cell operates
- Generates electricity as long as it has fuel
- Compressed gas storage of over 700 bar (10,000 psi)
- Hydrogen’s properties and difficulty in detecting leaks
- Management and removal of water vapor and liquid water
- Unique vehicle and building codes and standards

All Energy We use Originated in a Star

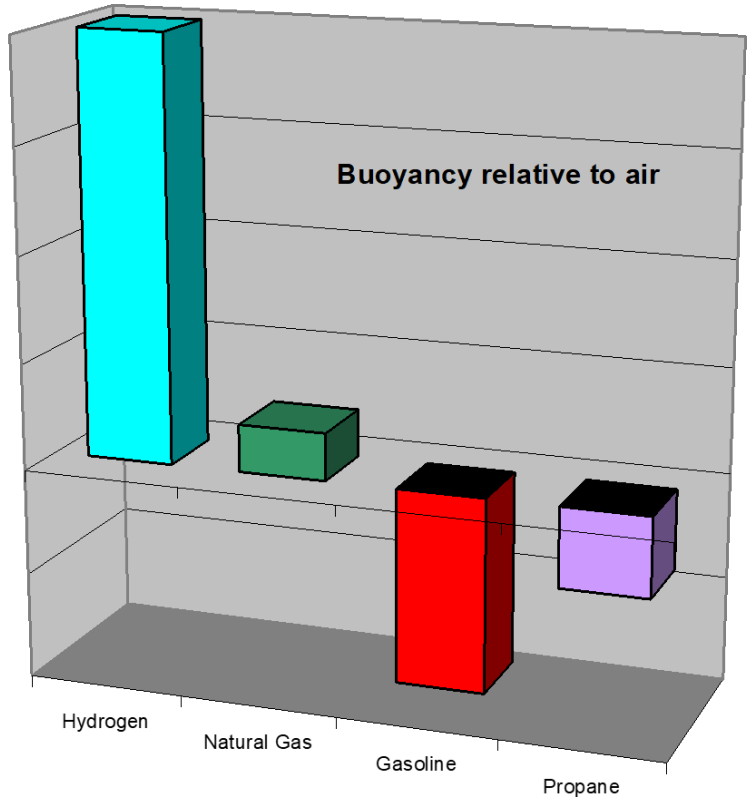


Hydrogen Bouyancy

How fast does it rise?

"Hydrogen rises 2 times faster than helium and 6 times faster than natural gas, at a speed of almost 45 mph (20m/s)."

--National Hydrogen Association; Hydrogen Safety Fact Sheet

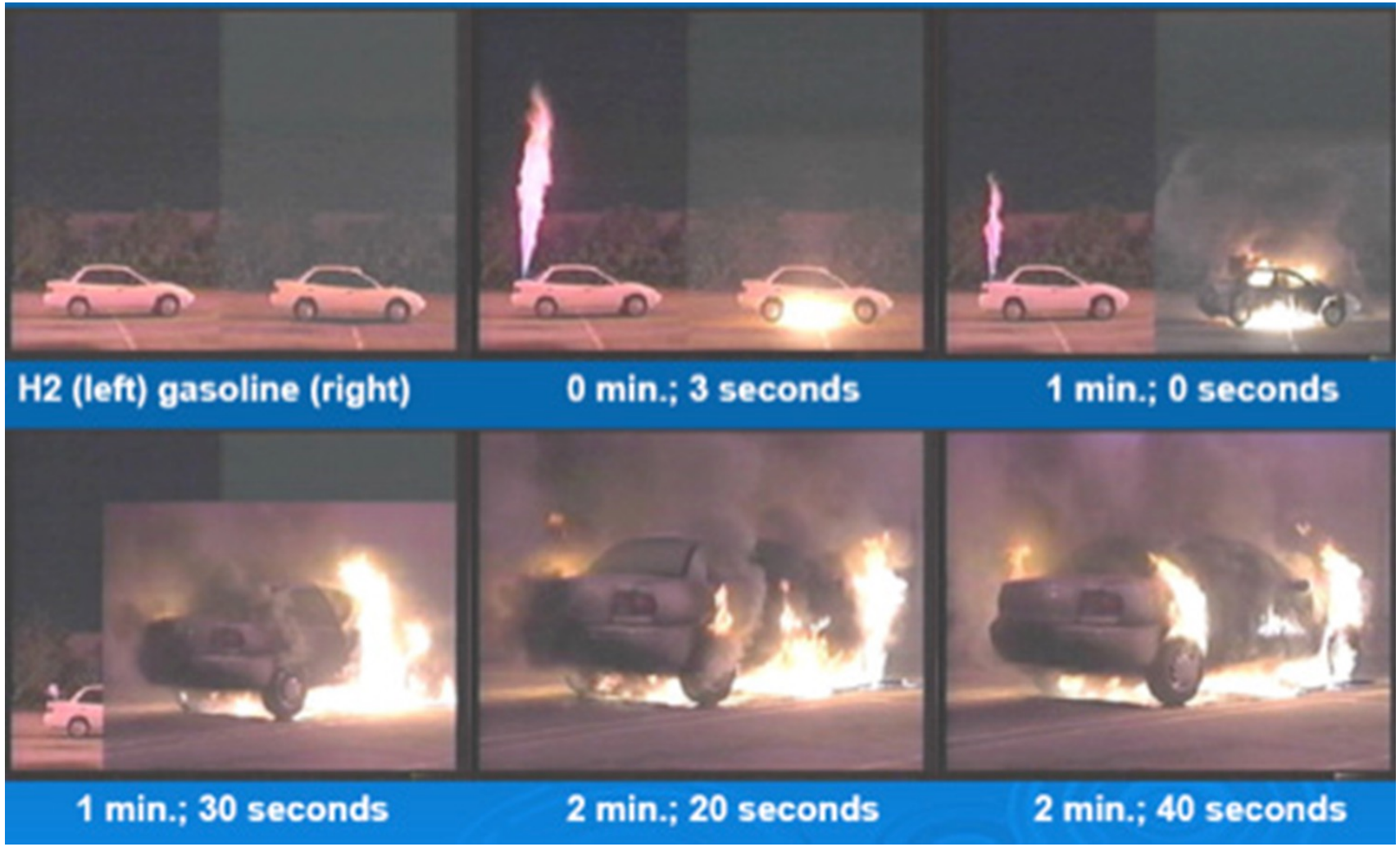


Courtesy of Ballard

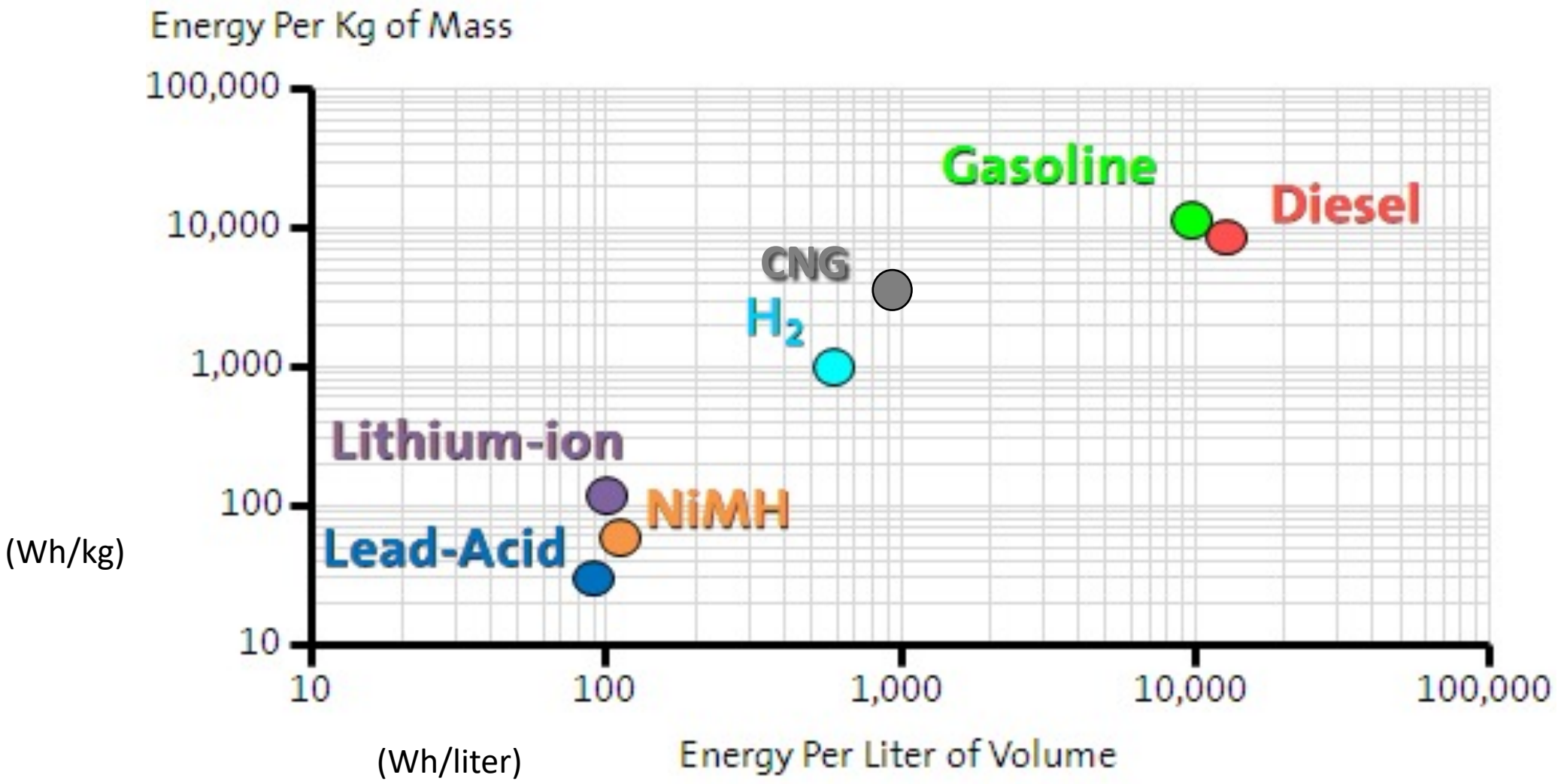
Comparison of flammability of fuels

	Hydrogen	Natural Gas	Gasoline
			
Flammability in air (LFL – UFL)	4.1% - 74%	5.3% - 15%	1.4% - 7.6%
Explosive limits in air (LEL – UEL)	18.3% - 59%	5.7% - 14%	1.4% - 3.3%
Most easily ignited mixture in air	29%	9%	2%
Flame temperature (°C)	2045	1875	2197

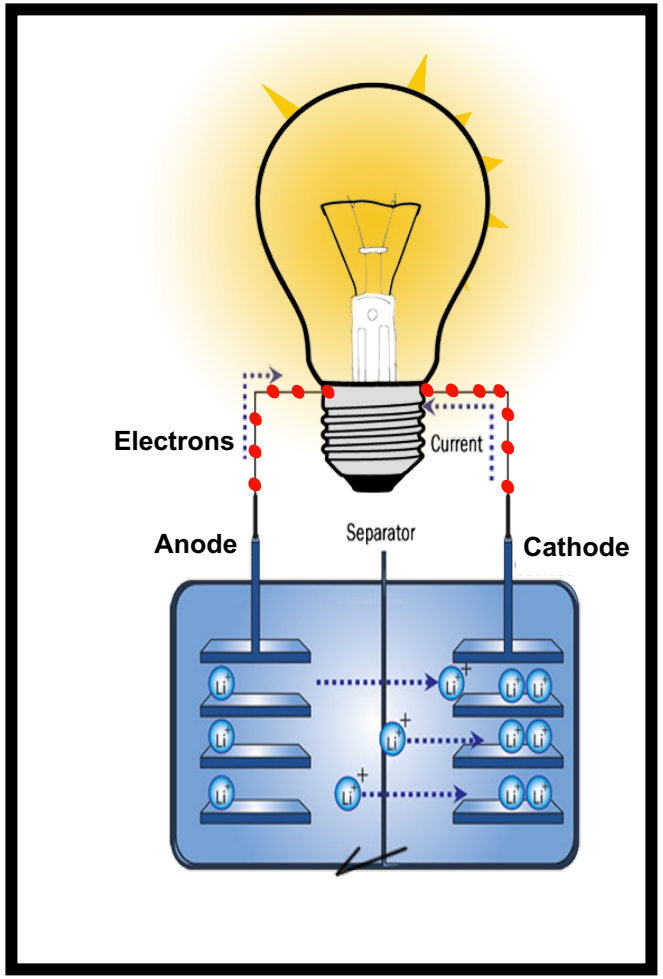
Gasoline versus Hydrogen Vehicle Fire

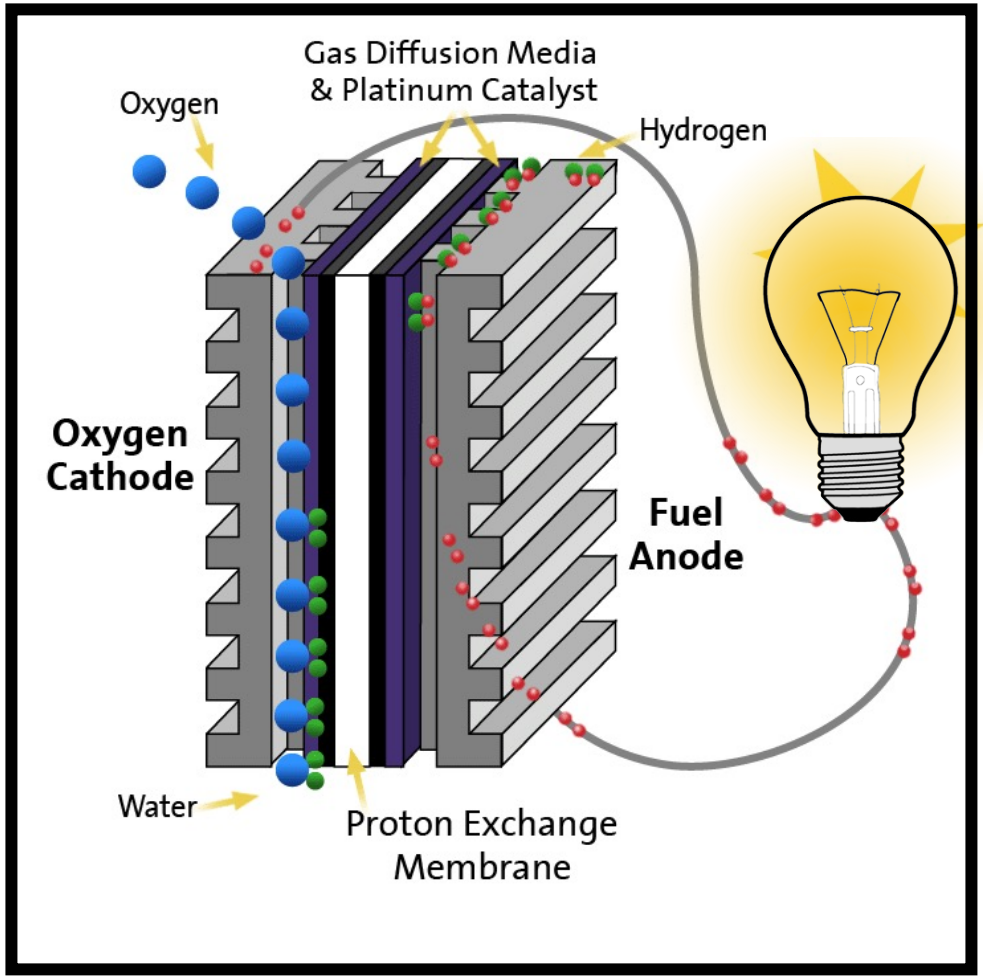


Hydrogen Versus Other Energy Carriers



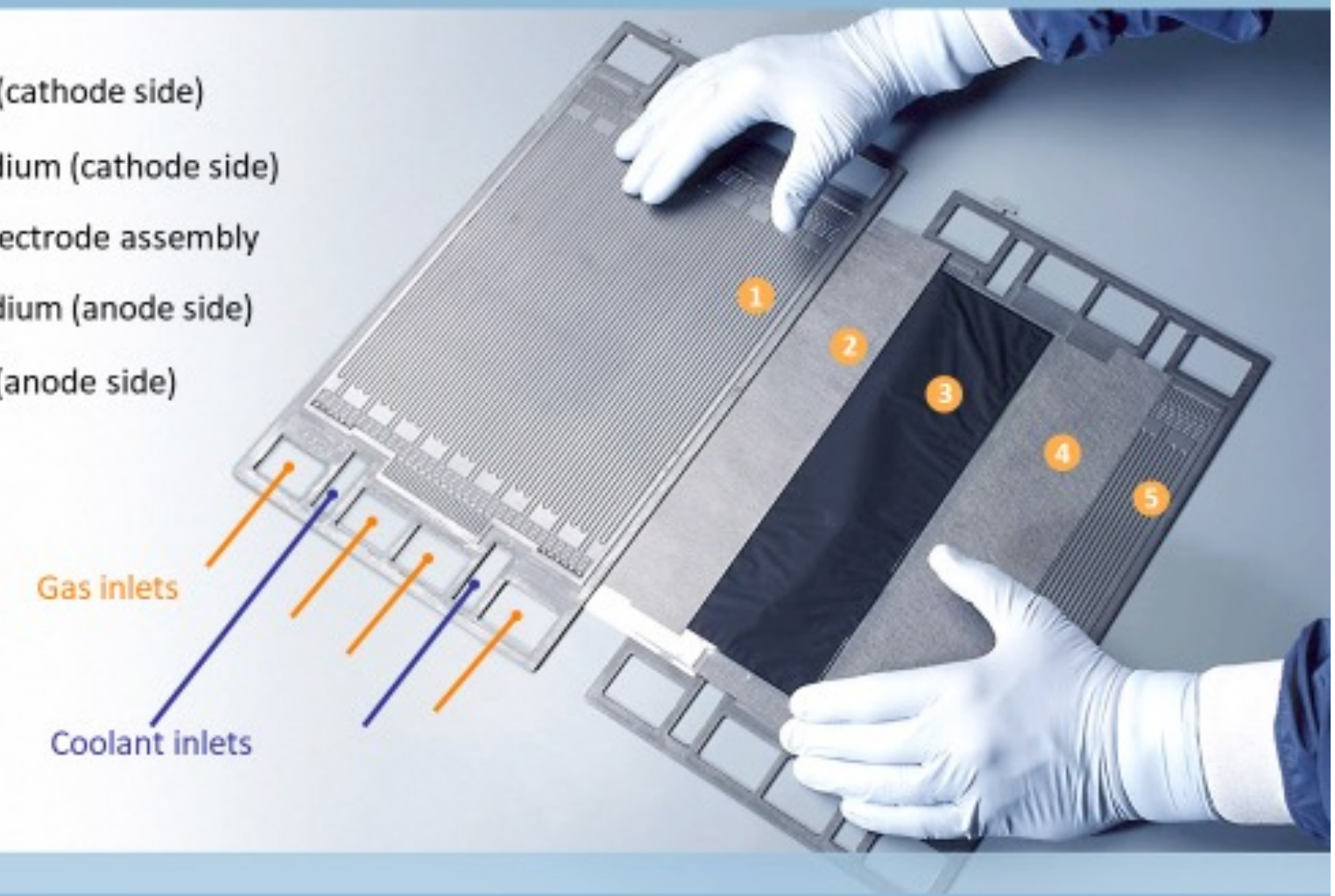
How a Battery Operates versus a Fuel Cell



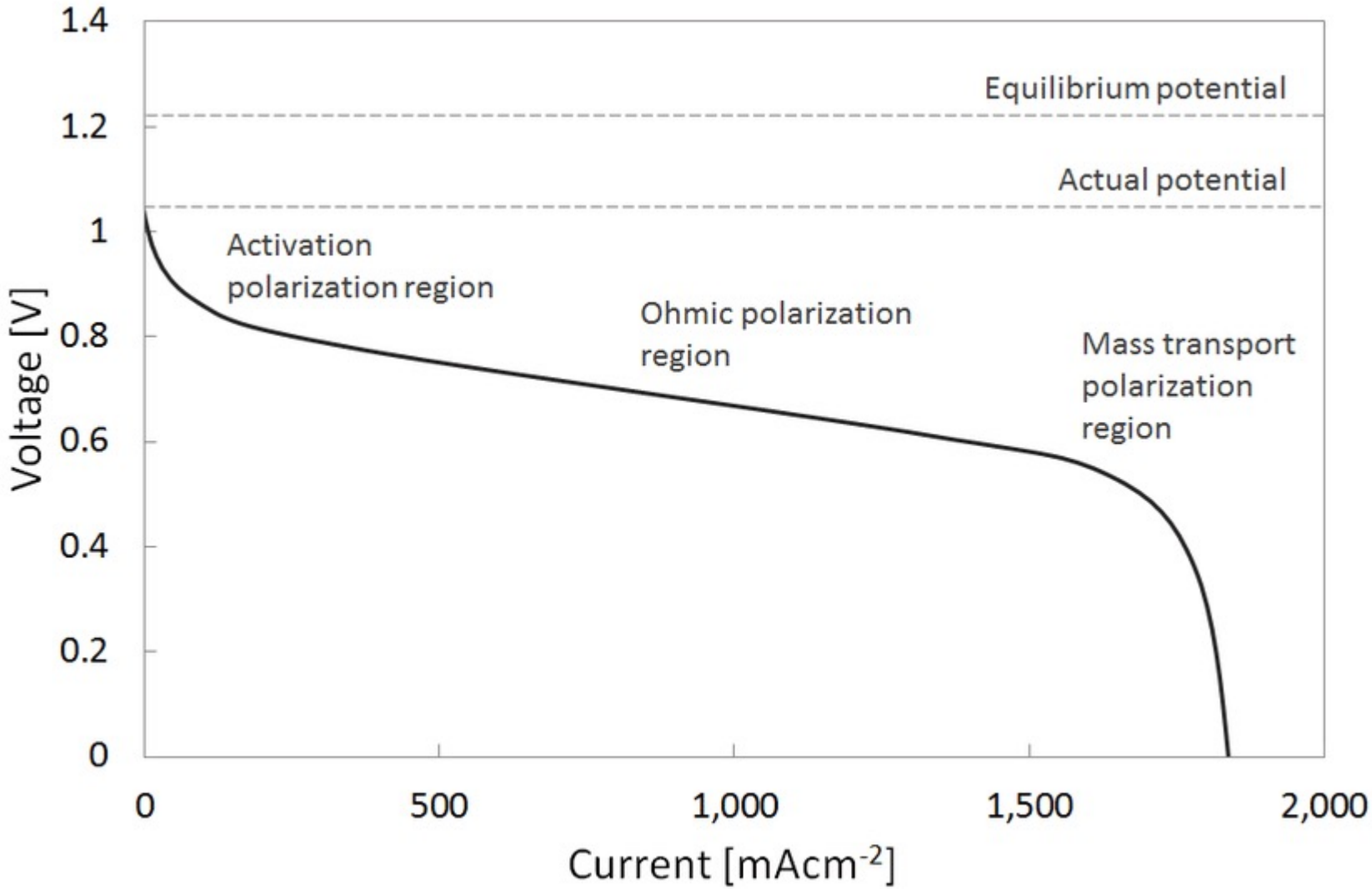


Fuel Cell Components

1. Bipolar plate (cathode side)
2. Diffusion medium (cathode side)
3. Membrane electrode assembly
4. Diffusion medium (anode side)
5. Bipolar plate (anode side)

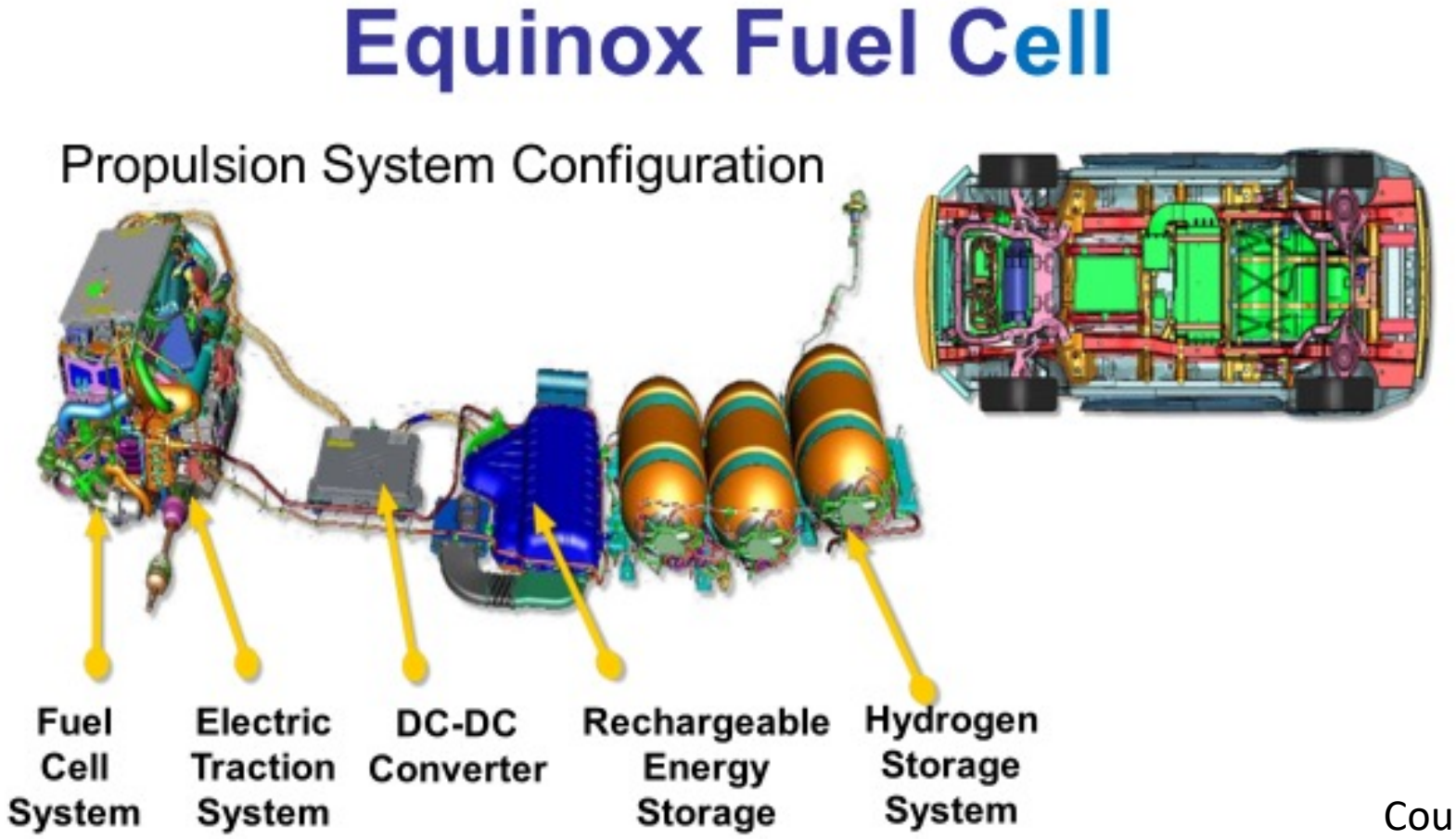


Typical Fuel Cell Polarity(POL) Curve

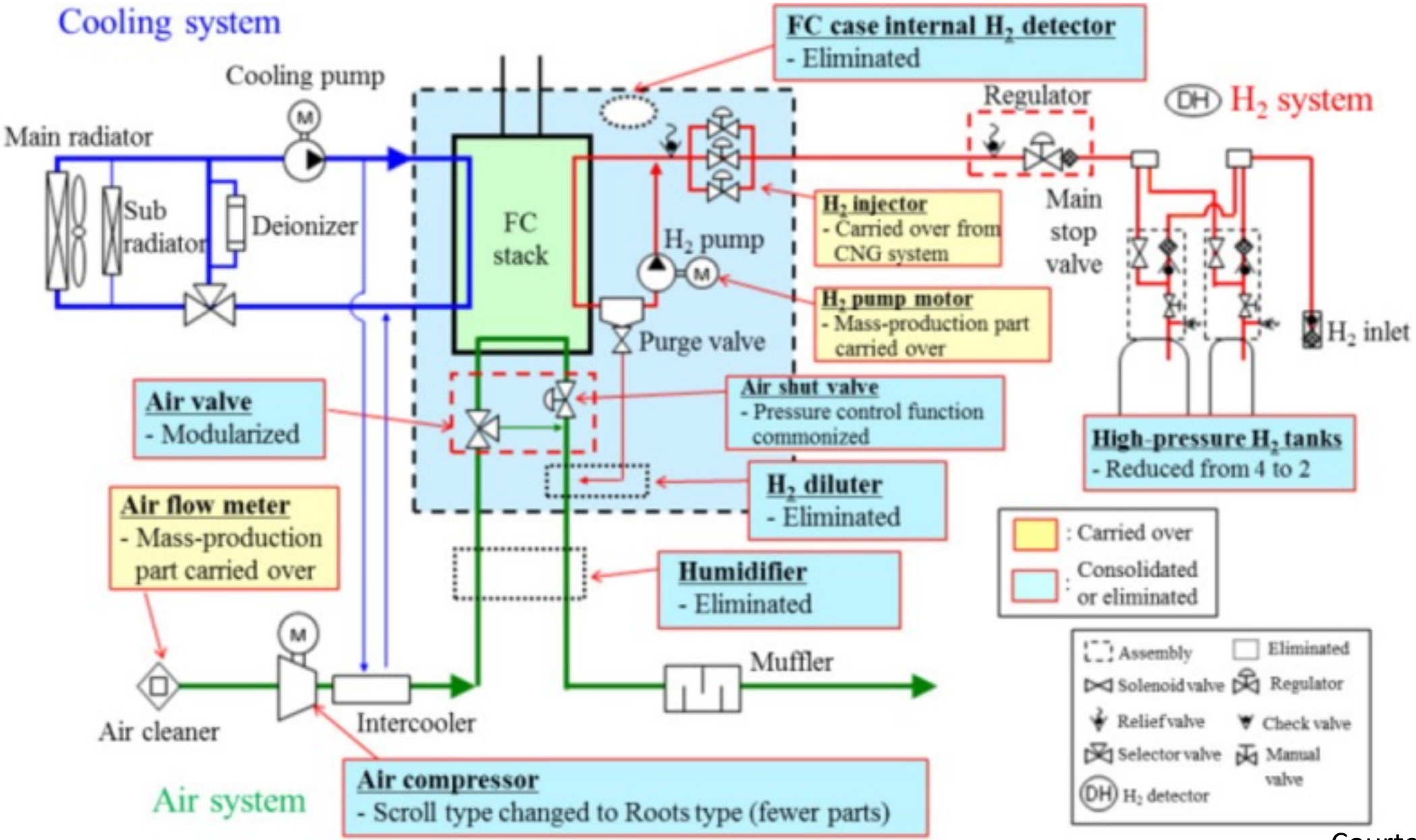


Valle, Francesco. (2015). Electrocatalyst degradation in high temperature PEM fuel cells.

Major Fuel Cell Vehicle Subsystems



Courtesy GM



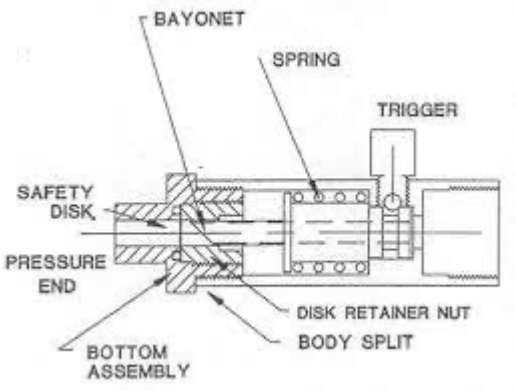
Courtesy Toyota

PPE and Hydrogen Safety

Flammmable Gas Detector

Hydrogen Detector

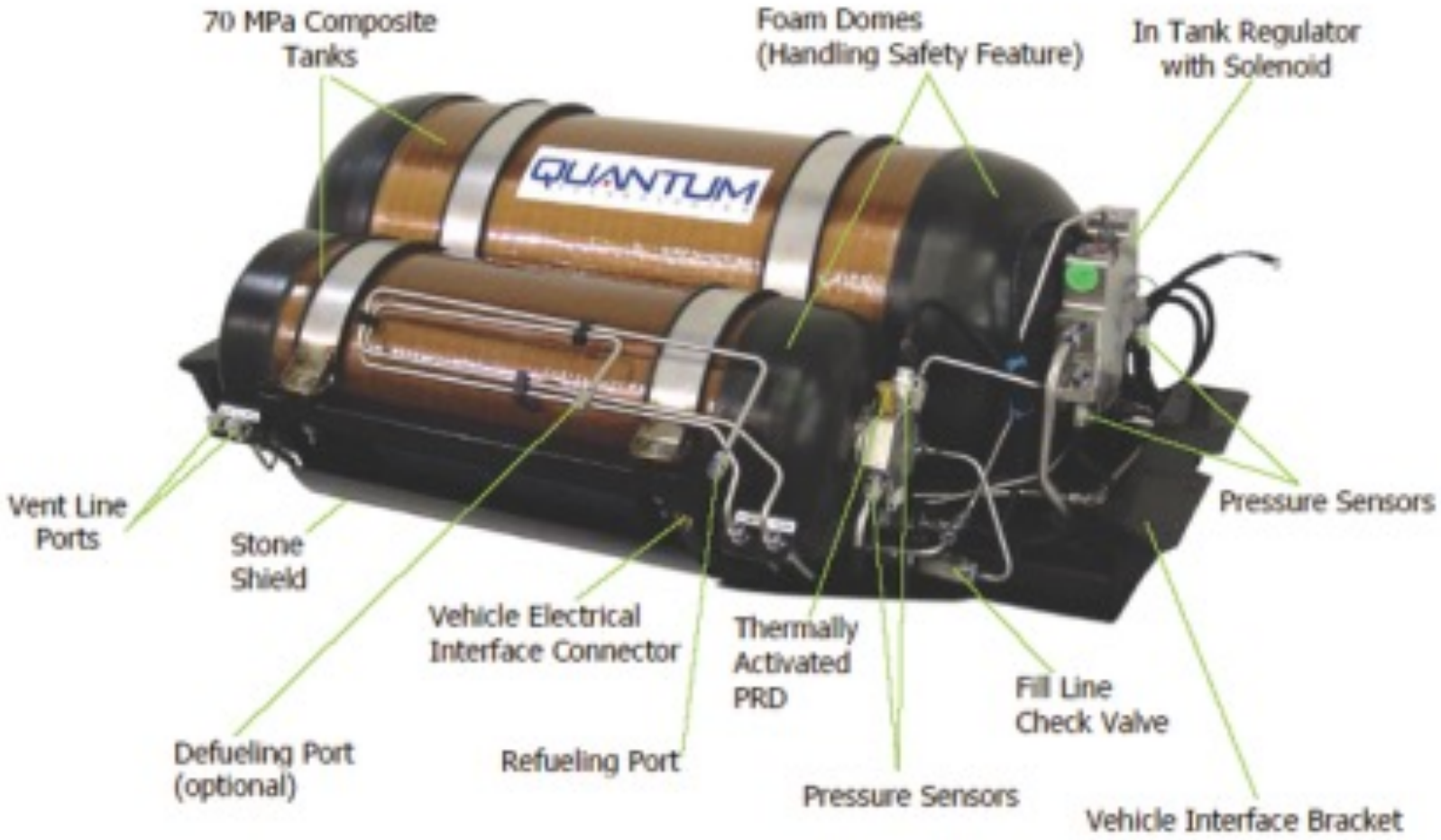
Nomex Garments



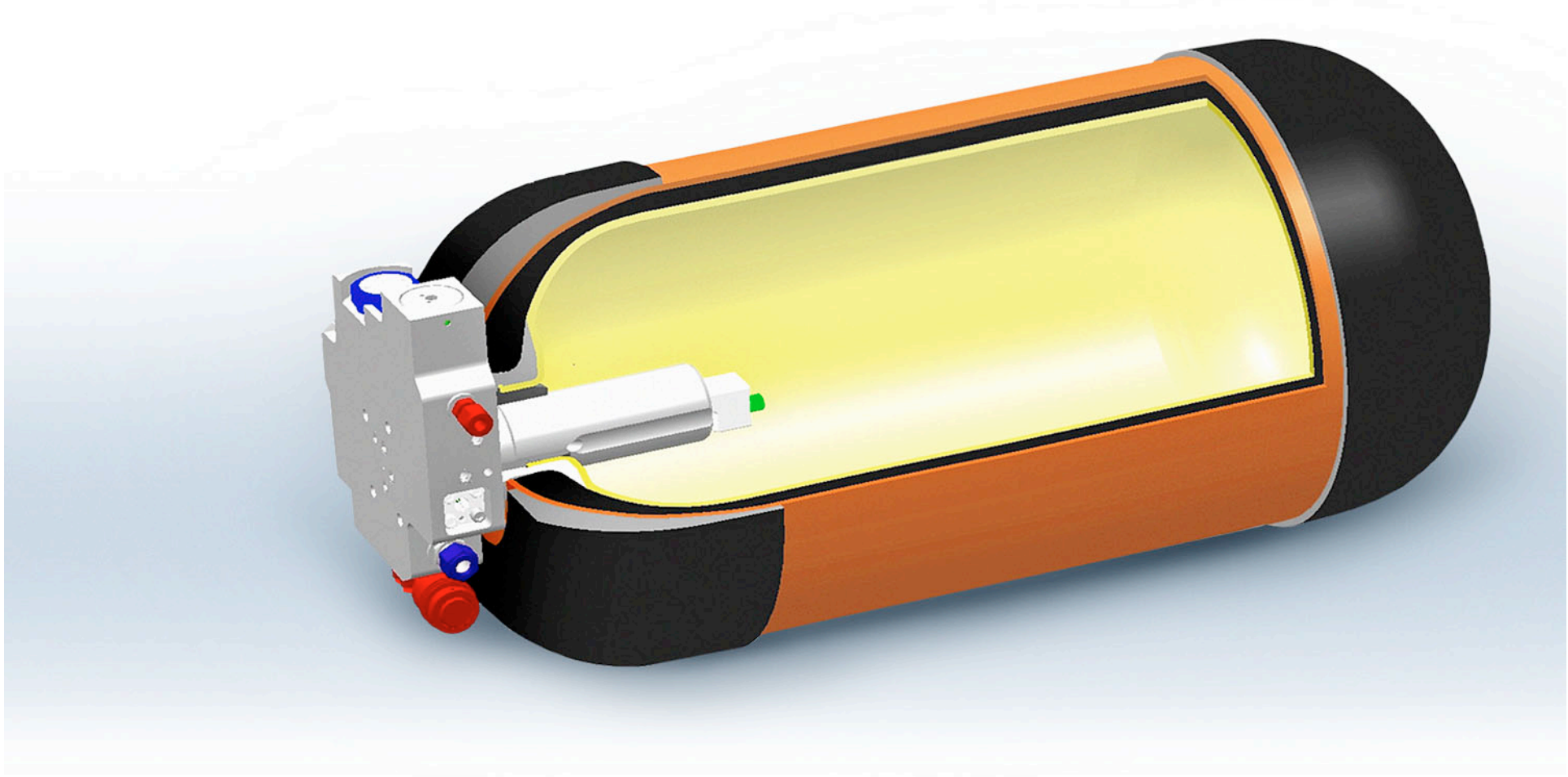
PPE and Hydrogen Safety

- XIV-a Hydrogen PPE
- XIV-b Hydrogen Personal Safety
- XIV-c Hydrogen Facility Safety
- XIV-d Compressed Gas Safety

Hydrogen Storage System



Compressed Gas Storage Vessel Type IV



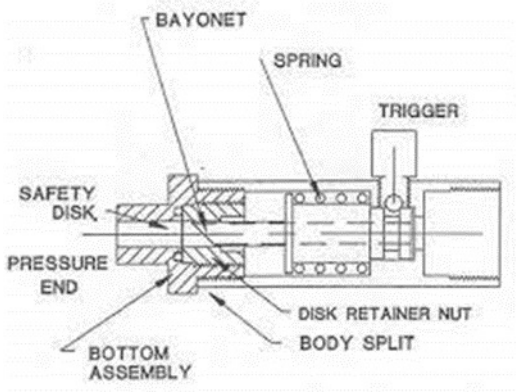
Hydrogen Storage System

On Tank Valve

Pressure Sensor

Regulator

Filter



PRD

Receptacle

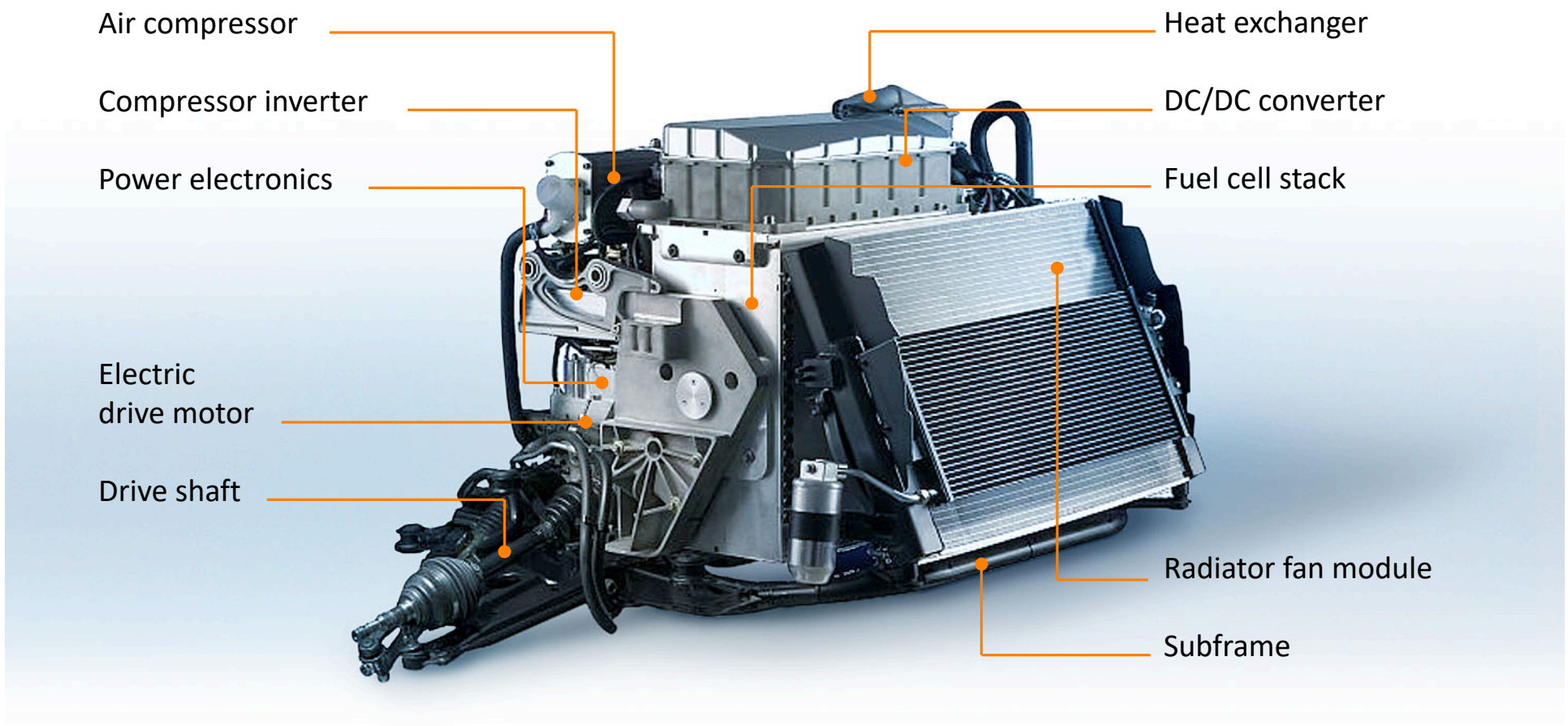
Hydrogen Storage System

- XV-a Theory and Operation of Hydrogen Storage Systems
- XV-b Hydrogen Storage System Schematics
- XV-c Hydrogen Storage System Pressure Vessels
- XV-d Hydrogen Storage System On Tank Valve
- XV-e Pressure Regulation and Regulators

Hydrogen Storage System (cont.)

- XV-g Pressure Relief Devices
- XV-h High Pressure Fitting, Connections and Tubing
- XV-i High Pressure Leak Detection Systems and Methods
- XV-j Inerting Pressure Vessels and Systems
- XV-k ECM & Software for Hydrogen Storage Systems
- XV-l Fueling Hydrogen Vehicles

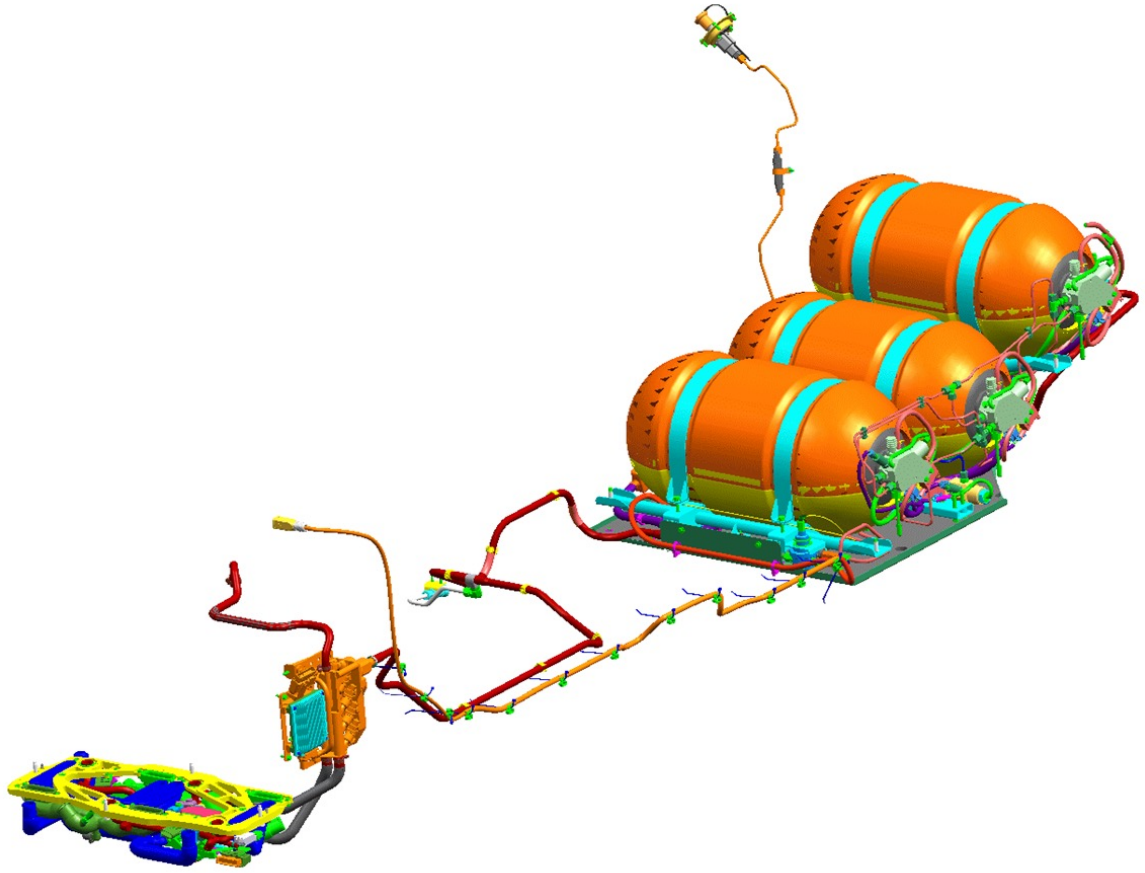
Fuel Cell Propulsion System



Fuel Cell Stack System

- XVI-a Fuel Cell Theory and Operation
- XVI-b Fuel Cell System Schematics
- XVI-c Constant Voltage Monitoring
- XVI-d ECM & Software for Fuel Cell Systems
- XVI-e Fuel Cell Propulsion System Overview

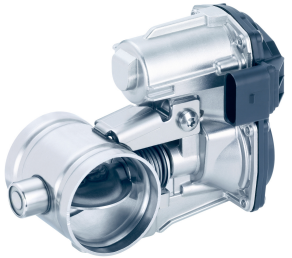
Anode Subsystem



Anode Subsystem Components

Humidification unit

Injector



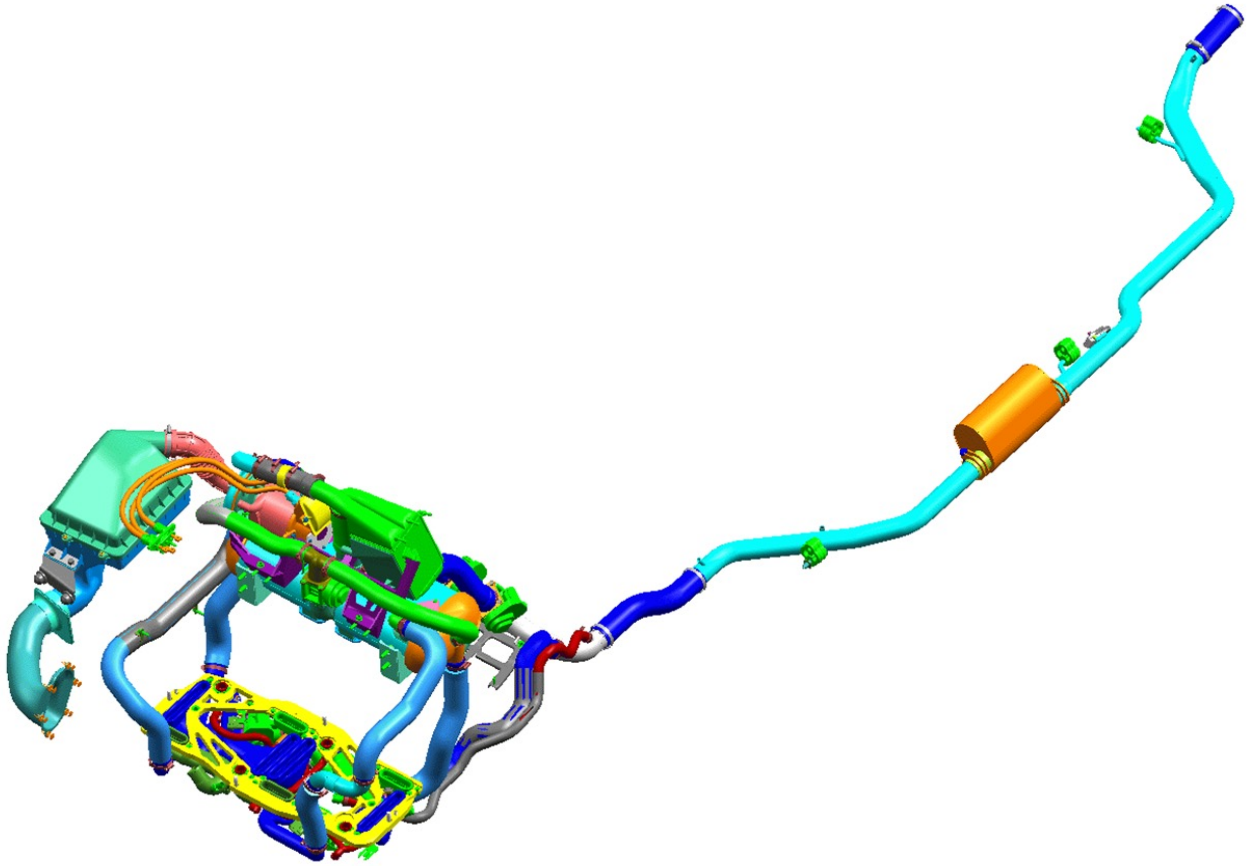
Control Valve

Hydrogen recirculation

Anode Subsystem

- XVIII-a Anode Subsystem Mechanization
- XVIII-b Hydrogen Injection and metering
- XVIII-c Hydrogen Recirculation Pump
- XVIII-d Nitrogen Purging
- XVIII-e Liquid Water Removal
- XVIII-f Anode Outlet Valve

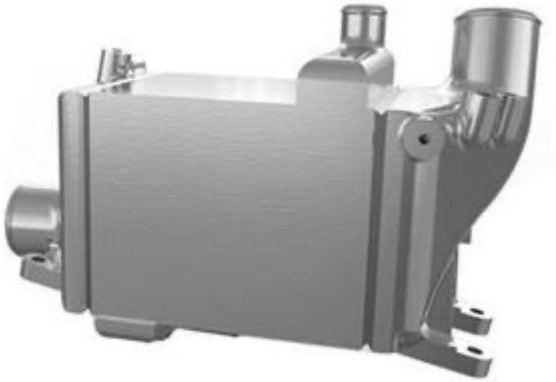
Cathode Subsystem



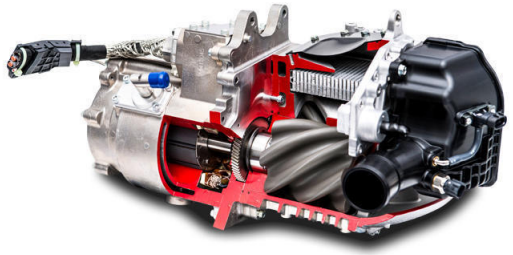
Cathode Subsystem Components

Drain Valve

Air Cleaner



Charge Air Cooler



Compressor

Sensors

Mass Flow Sensor

Cathode Subsystem

- XVII-a Cathode Subsystem Mechanization
- XVII-b Air Filtration
- XVII-c Mass Airflow Sensor
- XVII-d Compressors and Turbo Machines
- XVII-e Charge Air Cooler
- XVII-f Air Flow Valves
- XVII-g Exhaust System
- XVII-h Pressure, Temperature and Humidity sensors
- XVII-i Humidification Unit

Cooling System

HV Coolant Pump

Coolant Heater

Coolant Filter

Low Conductivity Coolant

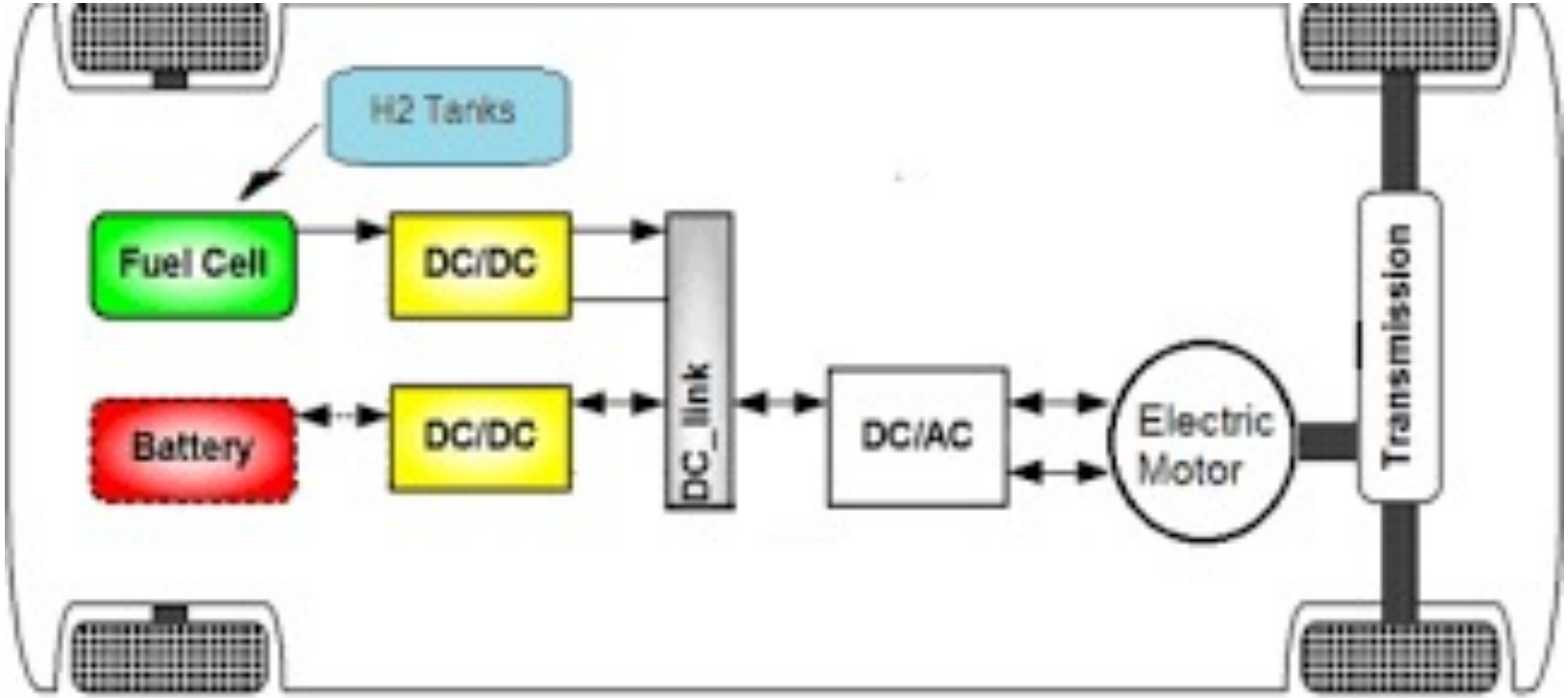
Heat Exchanger

HV Coolant Fan

Fuel Cell Cooling System

- XIX-a Cooling System Theory and Operation
- XIX-b Coolant Pump
- XIX-c Coolant Bypass and Control Valves
- XIX-d Coolant Heater
- XIX-e Coolant, Coolant Reservoir, Ion Exchange and Particulate Filters
- XIX-f Heat Exchangers and Fans

Fuel Cell High Voltage Schematic



Fuel Cell High Voltage

- **XX-a Fuel Cell Vehicle High Voltage Safety**
- **XX-b Fuel Cell Vehicle Specific High Voltage Components**

Specialized Equipment and Tools

- Standard EV high voltage test equipment
- Bottled gases, regulators, hoses and refueling nozzle
- Portable or fix vent stacks
- Vehicle specific hand tools, adapters and analyzers
- Leak detection (ultrasonic and hydrogen)
- Differential gas flow measuring equipment

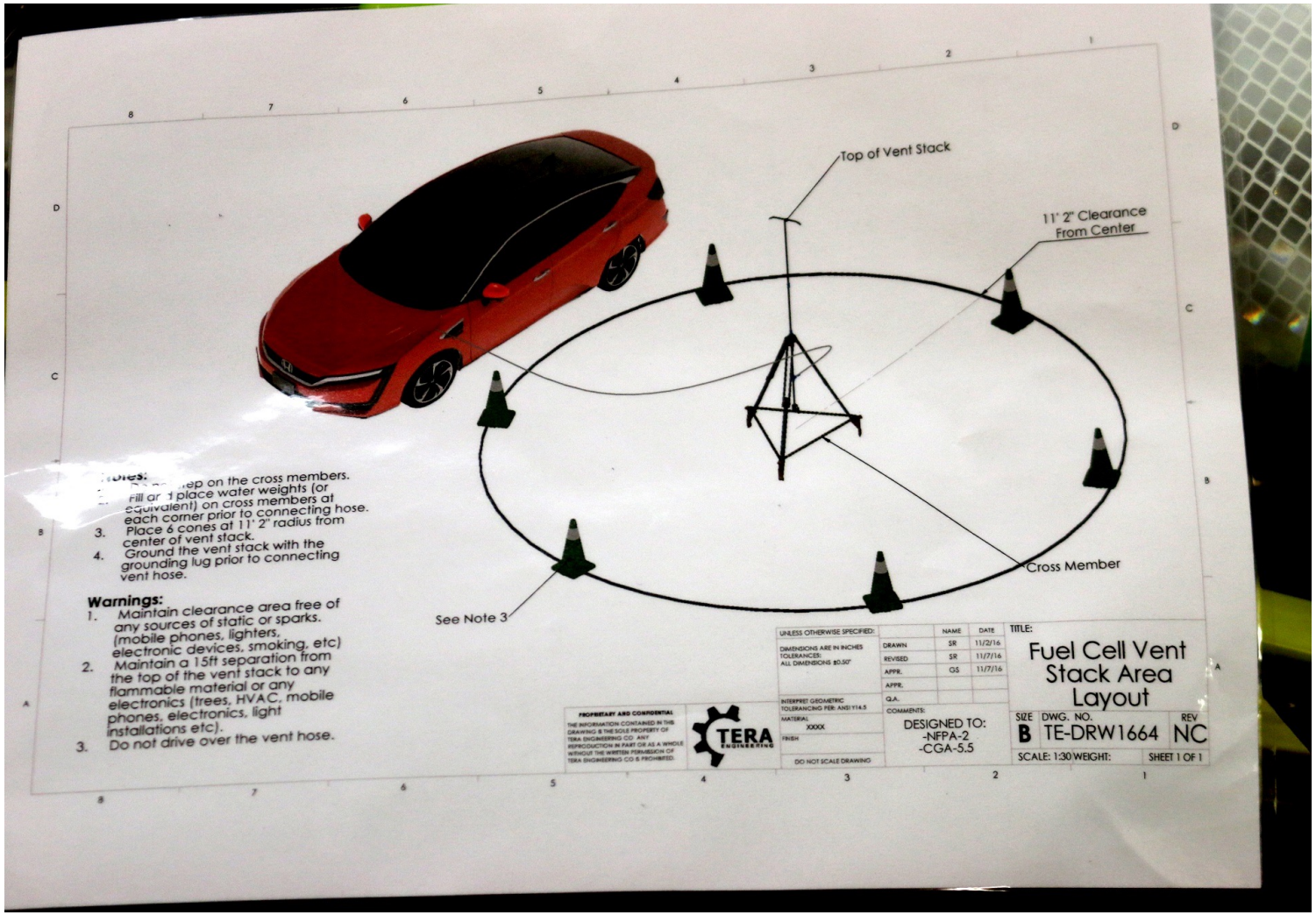
Codes and Standards

- ASME B31.3: Code for Chemical Plant and Petroleum Refinery Piping
- ASME Boiler and Pressure Vessel Code, Section VIII: Rules for the Construction of Pressure Vessels
- CGA 5.4: Standard for Hydrogen Piping Systems at Consumer Locations
- CGA 5.5: Hydrogen Vent Systems
- CGA S-13: Stationary Storage Containers for Compressed Gases
- CSA America HGV4: Hydrogen Fuel Dispensing Equipment and Components
- International Building Code
- International Fire Code
- International Fuel Gas Code
- NFPA 30A: Code for Motor Fuel Dispensing Facilities and Repair Garages
- NFPA 50A: Standard for Gaseous Hydrogen Systems at Consumer Sites

Codes and Standards

- NFPA 52: Compressed Natural Gas (CNG) Vehicular Fuel System Code
- NFPA 70: National Electric Code
- NFPA 853: Standard for the Installation of Station Fuel Cell Power Plant Systems
- SAE J 2719: H2 Quality Specification Guideline for Fuel Cell Vehicles
- SAE J1766: Post Vehicle Collision Electrical Energy Storage Safety
- SAE J2578: Recommended Practice for General Fuel Cell Vehicle Safety
- SAE J2579: Recommended Practice for Hazardous Fluid Systems in Fuel Cell Vehicles
- SAE J2600: Compressed Hydrogen Vehicle Fueling Connection Devices
- SAE J2601: Compressed Hydrogen Vehicle Fueling Communication Devices

Fuel Cell Vehicle Defueling Outdoors



Courtesy Honda

Features Building and Structure

Special Building/Structure Requirements to Service Fuel Cell Vehicles

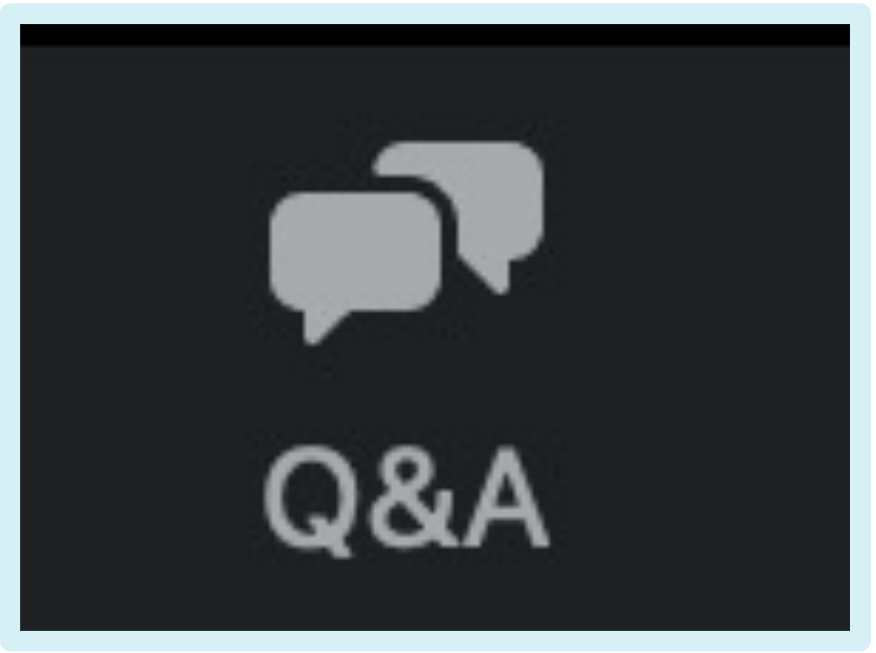
- Facility with hydrogen detection or an open outdoor service area
- Flammable and nonflammable compressed gas storage area
- Permanent vent stack or portable stack with a large enough exterior space to comply with fire code setback requirements

Fuel Cell Vehicle Service Certification

- This course of study was designed to be in added to the previously described EV certifications
- It can be modified to be a stand alone certification without prerequisites using specific modules from the EV certification program
- The program has a more extended time frame for light vehicles versus the EV program
- It is applicable to any type of fuel cell vehicle maintenance

Questions?

Type your question in the questions box.



Dr. Mark Quarto

Dr. Mark Quarto has supported alliances and customers in the development of electric propulsion and energy management power systems for over 33 years.

His former work for 28 years with General Motors consisted of developing propulsion and battery pack systems for the GM EV1, Chevrolet Tahoe/Yukon Hybrid, Chevrolet Spark EV, Chevrolet Volt, and numerous demonstration fleet electric and fuel cell products. His specialty is developing diagnostic systems, diagnostic information, and pioneering control systems that permit innovative diagnostic techniques, and diagnostic tool development.

His passion for educating and training the next generation of automotive technicians and engineers has connected him with many international educational projects. Dr. Quarto provides instruction on hybrid, electric, and plug-in vehicle systems for the SAE, OEMs, Tier 1 suppliers and in the college environments. He is a patent holder for electric drive systems, testing tools, and battery testing processes.

He holds a Doctorate in Technical Education on Hybrid Systems from Nova Southeastern University, Master's Degree in Electric Machine Technical Education, and Bachelor Degrees in Electrical Engineering and Automotive Technology

Questions?

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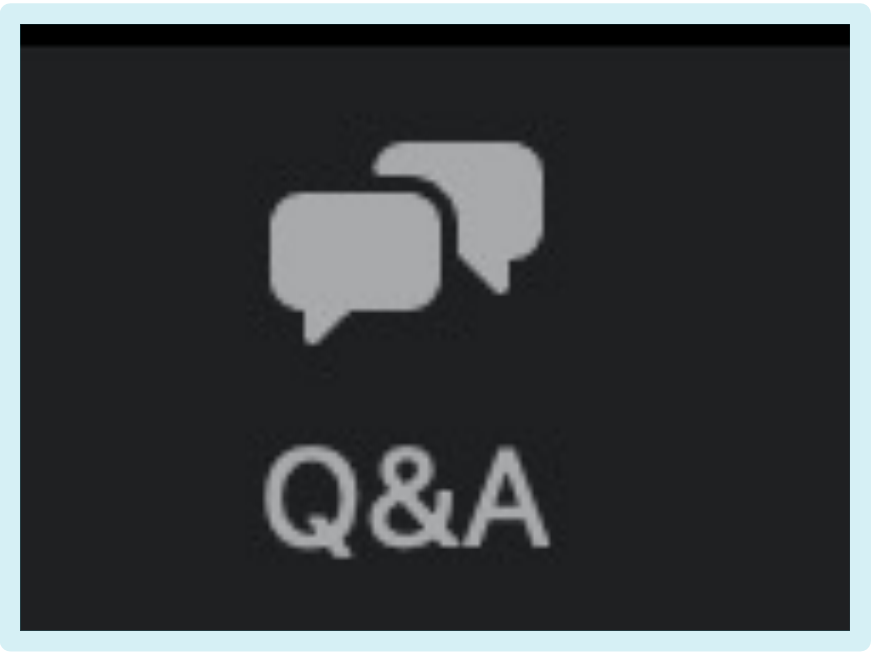

Discussion

Ask questions using the Q&A box.

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NEVTEX Consultant
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John Frala

Professor Alternative Fuels
Rio Hondo College

Thank you


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atl
Advanced Transportation
and Logistics
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